REMARKS

In the Office Action mailed 06/27/2003, the Examiner objected to Figure 1 of the drawings. A proposed drawing correction is attached. The Examiner rejected claim 1 under 35 U.S.C. s. 102(b) as anticipated by Nowick US Patent No. 3,970,160 or Kumar US Patent No. 5,998,880; rejected claims 2, 3, and 5-19 under 35 U.S.C. s. 102(b) as anticipated by Kumar; and claim 4 was objected to as dependent upon a rejected base claim but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claims 1, 2, 3 and 7 have been canceled. New claims 20 - 60 have been added. It is submitted that the presently submitted claims patentably distinguish the prior art.

Kumar US Patent No. 5,998,880

Kumar describes a well-known diesel locomotive with AC traction motor configuration. This is a diesel engine that drives an alternator whose output is rectified and sent along a DC link to individual inverters associated with each AC traction motor. The principal purpose of Kumar's invention is to eliminate "*the need for a DC link current sensor in an AC traction motor vehicle system. All of the functions performed by the DC link current sensor in an AC traction motor vehicle system are implemented using existing measured parameters.*" (Column 2, lines 22-27)

In general, the inverters supply AC power to each AC traction motor and are all in phase with each other. Unlike the present invention, there is no time phasing or time-shifting of the sinusoidal pulses to each motor which would reduce the instantaneous DC current draw. The power pulses are generally in sync

throughout the operation of the locomotive and wheel slipping is counteracted by reducing power to all motors at the same time, contrary to the present invention as claimed. Also, power level is changed by varying the frequency of the AC power from the inverters. The present invention varies pulse width, not frequency.

Kumar is only providing an alternate means of determining the DC current in the DC link. Kumar's AC motors are not individually controlled, just individually sensed for his alternate DC current determination. Thus Kumar does not teach how to achieve the benefits provided by the present invention.

Nowick US Patent No. 3,970,160

Nowick discloses a hybrid vehicle (Fig. 4) where the prime energy source (a combustion engine) can provide significant power. The problem which Nowick addresses is steering control. Nowick does not address wheel slipping since the application is directed to highway vehicles, not locomotives, does not address optimizing battery performance and does not address time-sequence power pulses to individual motors except for purposes of steering. Nowick provides individual synchronized motors for each of two wheels on a small personal vehicle. Nowick provides controllable pulses of power to each wheel but does not describe a chopper circuit for each motor. Instead Nowick provides a frequency dividing counter and undefined AND and OR switching devices. Synchronous motors are very different from DC traction motors.

In Nowick's vehicle, four operational modes are described. In two, rotation right and rotation left, power is supplied to one of the two wheels only while the other wheel is stopped. The other two modes are forward and reverse. In both these modes, power is supplied simultaneously to each wheel while

driving straight. The timing of power pulses is shifted to each wheel (a higher frequency on one wheel, a lower on the other wheel) to effect power steering by the two driving wheels. When the vehicle is commanded to make sharp turns, the timing of power pulses to each wheel can be substantially different. In general, power pulses are simultaneous which is why synchronous motors are specified. DC linear induction motors require part of the motor to be embedded in the guide way so they cannot be equated with DC traction motors. Thus in Nowick the pulses to each of the two motors generally are temporally overlapping (coincide in time). Only when turning, do the pulses not coincide in time. In the present invention power pulses do not overlap at low speed which provides for maximum spacing between pulses. When Nowick's pulses do not overlap, the spacing is not the maximum spacing possible but is dependent on the degree of turning. Further, Nowick varies power to individual synchronized motors by varying the pulse frequency while maintaining a constant pulse width.

According to the disclosed invention, power is extracted from an energy storage battery pack by commanding time-sequenced power pulses to individual chopper circuit/DC traction motor arrays. Power to each motor is increased by increasing pulse width while maintaining frequency constant. Power from the battery is drawn at different times for different motors by starting the power pulses to each motor at a constant offset from neighboring pulses. At low power settings, the power pulses from the battery to each motor are not overlapping. As the commanded power increases, the power pulses are widened so that eventually neighboring power pulses overlap. Thus at low speed, the motor current pulses are maximum amplitude. As speed increases, the motor develops a back emf which reduces the amplitude of the current pulses. This is compensated for by increasing pulse width.

The logic control used by the present invention allows for pulse widths to individual motors to be controlled independently. Normally, all pulse widths are increased or decreased by the same amounts. However, if required, for example with non-synchronous wheel slip, the power pulses width of an individual motor can be modified differently than those delivered to the other motors.

Also, it is noted that the present invention uses a chopper circuit to chop the DC power into discrete pulses while the DC motor itself mechanically inverts the voltage by virtue of the armature rotation unlike an AC traction motor where an inverter inverts and shapes the waveform applied to the AC motors. The present method is suited to a large energy storage battery pack. The specification describes the following surprising, non-obvious benefits of the invention as claimed:

a) The spacing of the current pulses results in individual instantaneous current requirements that are not additive. (Page 7, lines 25, 26). It follows that the instantaneous current requirement from the battery are not additive so that battery internal heating (I^2R) is lessened which results in longer battery life and less frequent battery failure and maintenance.

b) The independence of individual current requirements has the positive effect of minimizing the input filter requirements. (Page 7, lines 26, 27) The size and number of the filter capacitors associated with each chopper circuit can be reduced which saves space (these are large energy storage capacitors) and cost, and there are fewer capacitors to give problems and require maintenance.

c) With a minimum amount of capacitors, low source impedance is achieved,

which is important to the operation of the drive. (Page 7, lines 28, 29) Lower source impedance for the drive means lower source impedance to the chopper circuit and therefore less current drop while free-wheeling.

d) A further benefit of the invention, derived from the flexibility of individually controlling power to a plurality of DC motors, is an efficient and effective approach to correcting wheel slip in a rail locomotive application. (Page 7, lines 31-33) The claimed method provides for control over non-synchronous as well as synchronous wheel slip.

e) The claimed method provides a control system to limit the current drawn from the power source as well as the individual currents drawn by each of the motors. (Page 8, lines 7-9) The current drawn from the power source is limited in 3 ways. (1) A maximum current set point keeps the current draw from exceeding a pre determined amount. (2) As axle speed increases, the back emf reduces instantaneous current draw. (3) By time sequencing current pulses (same as power pulses since motor driving voltage is fixed by battery pack voltage output), the current draw is reduced.

In summary, the prior art does not anticipate or suggest the benefits of varying power to individual DC motors by varying the pulse width. Nor does the prior art anticipate or suggest the benefits of applying pulse width modulation to a plurality of DC traction motors by time-sequencing the pulses to individual motors such that the time separation between pulses to different motors is always maximized Both Kumar and Nowick vary power by varying the frequency of pulses, not by varying pulse width as done in the present invention. Further, the power pulses in both Kumar and Nowick generally overlap. The benefits of sequencing the pulses so that they do not overlap to the maximum extent was not foreseen in

the prior art.

It is submitted therefore that the amended claims are allowable, and issuance of a Notice of Allowance is respectfully requested.

Respectfully submitted,

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